WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵: B25J 21/00, H02K 16/00

A1

(11) International Publication Number:

WO 94/23911

(43) International Publication Date:

• • •

27 October 1994 (27.10.94)

(21) International Application Number:

PCT/US94/04040

(22) International Filing Date:

13 April 1994 (13.04.94)

(30) Priority Data:

08/048,833

16 April 1993 (16.04.93)

US

(71) Applicant: BROOKS AUTOMATION, INC. [US/US]; 41 Wellman Street, Lowell, MA 01851 (US).

(72) Inventor: HOFMEISTER, Christopher, 176 Wheetwright Road, Hampstead, NH 03841 (US).

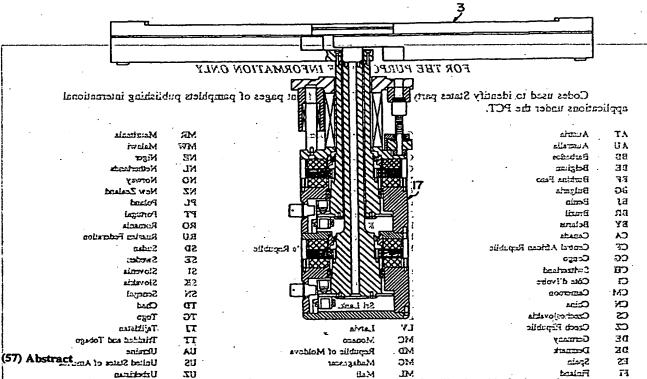
(74) Agent: NIELDS, Henry, C.; Nields & Lemack, Suite 8, 176 E. Main Street, Westboro, MA 01581 (US). (81) Designated States: CN, JP, KR, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published

With international search report.

BEST AVAILABLE COPY

(54) Title: ARTICULATED ARM TRANSFER DEVICE



A concentric-shaft rotational drive system for an articulated arm transfer device (3) adaptable for imparting movement to an assembly inside a vaccuum chamber (2) wherein rotary movement is imparted to rotors (7, 9) inside the vaccum chamber (2) by means of magnetic

fields produced by stators (8, 10) outside the vaccum chamber.

POI

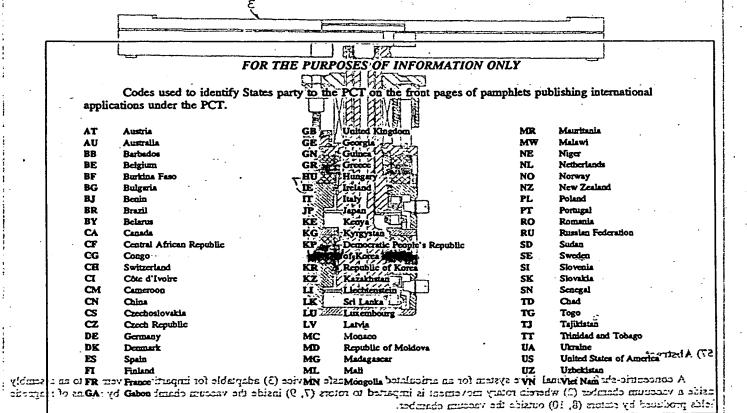
WORLD INTELLECTUAL PROPERTY ORGANIZATION International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

1) International Publication Number: WO 94/23911	(1) A1	(51) International Potent Claratication 5:
3) International Publication Date: 27 October 1994 (27.10 54)	A1 (4:	B25J 21/00, E(2K 16/00
(61) Designated States: CN, JP, KE, Europens patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, EE, TI, LU, MC, NL, PT, SE).		 [71] Interoctional Application Number: PCT/US94. [22] International Filtry Date: 13 April 1994 (13.
Fablished With international search report.		36) Priority Date: 62/040,633 16 April 1993 (16.04.93)
	:dಟ್ರ [†] ಗಳಾಲ	 72) Applicant: MRODES ALTON UTON, BNC. [NS.US. Wolfman Street, Levell, MA 1.051 (NS). 73) Inventor: HOFMINSTILL Chirapher, 176 Wheel Roosi, Hempstand, INI 63641 (US). 76) Agout: NELDS, Henry, C.; Wolds & Lemnik Suite S, Mais Street, Western, MA 01551 (US).

(54) Title: ARTICULATED ARM TRANSFER DEVICE



WQ_94/23911\TOS

a vafer ejector acceptor arm having directional air jets. The wafer ejector acceptor arm made defaulth and street ejector acceptor arm consideration or out of the carrier from or onto the air slide, which moves the wafers to or item a work acceptor.

U.S. Patent Nos. 4,062,463, 3,874,525 and 4,028,159 also disclose wafer transfer devices noifer and and being neuratic

10 Process imaging plates, such as The manufacturing process imaging plates, such as substrates, such as High Density Interconnects, semiconductor was masks or reticles, and large area display panels, such as Active Matrix action substrates. "All substrates are display panels, such as Active Matrix action substrates." "All substrates are display panels, such as Active Matrix action substrates." "All substrates are display panels, such as Active Matrix action substrates." "All substrates are display panels, such as Active Matrix action substrates." "All substrates are display panels, such as Active Matrix actions substrates."

2. Description of the Prior Art bescqsib berrelscard
20 The transfer of delicate silicon wafers of the like delicate and have the property of the like delicate are very delicate and have the problems.

There are numerous devices described in the prior art for a transferring silicon wafers. For example:

30 eviro a U.S. Patent No. estato, as a desclose an apparatus which discloses an apparatus which includes a supply dirier with a volutality of ledges to hold estato a the silicon wafers and a withdrawal device having a vacuum chuck. The vacuum chuck is estato to an elevator which estato and lowers the chuck. A horizontal transfer arm as a solutal transfer the silicon to the chuck of the chuck is a stato to transfer the silicon as a solutal transfer arm as a solutal transfer the silicon to the chuck is used to transfer the silicon

35 to coupled to the vacuum thuck is used to transfer the silicon leaving the vacuum thuck is used to transfer the silicon leaving the supply carrier to a leaving work station.

U.S. patent No. 3,370,595 discloses a wafer transfer

40

handling apparatus having an indexable carrier for transferring wafers to and from work stations. Wafers enter and leave the wafer carrier on an air slide with the aid of

WO 94/23911 TOT PCT/US94/04040

a wafer ejector acceptor arm having directional air jets. The wafer ejector acceptor arm controls the driving of the wafers into or out of the carrier from or onto the air slide, which moves the wafers to or from a work station.

U.S. Patent Nos. 4,062,463, 3,874,525 and 4,028,159 also 5 disclose wafer transfer devices which include either pneumatic vilcomponents or gripping devices for handling the wafers. ingim beU.S. Patent Nos. 4,666,366 and 4,909,701 disclose wafer 23 transfer handling apparatus having an articulated arm assembly 10 gaiwhich extends and retracts in a "froglike" motion to transfer To Jan Object such as a wafer between a plurality of locations. Two articulated arms are operatively coupled such that when xirone arm is driven by a motor the articulated arms extend and retract in a "froglike" or "frogkick" type of motion. platform is coupled to the arms and has the object to be 15 transferred disposed thereon or and to norder passe exil ed. 10 Patent No. 4,951,601 discloses wafer transfer of handling apparatus having an articulated arm assembly which prilition about a concentric-shaft, rotational drive system. However, such drive system requires rotary seals which can eval, bus essentiably view system requires rotary seals which can In the drive system of U.S. contaminate the vacuum chamber. nostria end esuas nas notices grantis sint series cause cause con cause con contractions according according to the contraction of the contraction riend of edition of the rest of the cause of It appears that the drive 115 which is rotated by a belt. 25 rotates in an aperture in the vacuum chamber, thus requiring a rotary seal. The hollow middle shaft 96 is mounted on a drive 101 which is rotated by a cable 103 mounted on a drive 30 and a drive which will work of the control of t dland which is rotated by a belt. It is not clear which block or leages to hold components are inside the vacuum, but it seems clear that some must rotate in an aperture in the vacuum chuck is accared to an elevator which chamber, thus requiring a rotary seal. The device of the present invention has no such rotary seals. All bearings of as the present invention are entirely within the vacuum, and all motivation is of isrias Ylugus and motivation and all

U.S. Fatent Norts, iddiscresses a water transfer handling apparatus having an indexable carrier for transferring wafers to and from work stations. Wafers enter and leave the wafer carrier on an air slide with the aid of

40

WO 94/23911 PCT/US94/04040

Figure 8 MOITMEVMI:: HT : 40:YARMMUZilar to that of Figure s doing nThe ipresent dinvention opprovides and geoncentric-shaft rotational drive system for an articulated arm transfer device adapted to transfer objects, such as silicon wafers, camera lenses, crystal coscillators for the like Abetween a plurality epms of placations; disposed in various axial and radial planes. no 2 flawThetdrived system permits the entire carticulated arm refrassembly to befrotated in a radial plane edlike the apparatus s agof theapriorgart, such rotation is done when the gend effector dentral aperture through .noition deporture aruta are tartion disable realtheadrive system salso spermits the splatform assembly to attable displaced in an axial direction. The assembly is adaptable end for use in a variety of environments, including operation in ers ativacuum; chamber sor other controlled cenvironment sat The 15:manassembly may be mounted for movement inside a vacuum chamber bodiwithea vacuum sealibetween the assembly and its supporte to one in which they rotate togather, and another in which sevies notice tembrief. Description (OFether Drawings and the view of the control restal enFigure, 1 is accentral rection; throught a dual eshaft device 20 mis constructed in accordance with the invention and aconnected so as to drive an articulated arm transfer device of the type end disclosed aine U.S. expatent No. 25, 180, 276 atoe Hendrickson and reduassigned to the assignee of the instant application; ruxe thad resigure 20istandetail roffa portion of the central section and attains a maximum outer diameter correspondinguing of 32 ensitua Figure B' is adetail of a portion of the central section the outer shaft 4, and a corresponding srupit to is ai e no:Figure Asissamplan viewmofothe devices of Figure 1133 a bus 'sFigure Seis and isometric sketchtof a priorbartodevice; .0 rod@Figure 65 istan plantoview of the rdevice of prigure 10 but 0. gnimodified to drive santarticulated arm transfer device of the end type adisclosed in compending sapplication Serial No. 1997, 773 filed December 128 v 1992 by Eastman and Davis and assigned to Each rotor-gnoitagilqqs7thesentfapplicationg-rotor nosi 35 zeire2 %Figure ent iss addentralomsection e along the oline v7-7 of 3. manufactured by MFM Technology, Inc., 200 Tibnse; atarugifue, Ronkonkoma, New York 11779.

WO 94/23911 TO9 PCT/US94/040401

Figure 8 Wis accentral section similar to that of Figure jishid-andushowing anothervembodimentwof the minvention in which a rotational drivebeyolqmer eraceshard contentation or ivebeyoldmer experience adapted to transfer objects, such as silicon wafers, camera lenses, MOITMEVAINS ET LIQUID SCRIPTION OF LINE RIVENTION, sesses .zensiq laiReferring to Figuresvicthrough 47 a mounting flange mis leis lattached to an apertured region of the bottom wall 2 of audsasyacuum chamberswithin iwhich ran barticulated; armimtransfer rosodevicers sis rsupported at a The amounting flange titself has a central aperture through which stwo sconcentric output shafts 10 of vextend: "The outer shaft is designated 4,2 and the inner shaft eldeissidesignated as a stat the rextremities of the soutput shafts mi nwithingtherivacuum chambers ampilot bearing 6 separates the adT shafts, and supports them upon each other ad The two shafts are 15 gamindependently rotatable me However, fin the preferred embodiment of the invention the relative motion of the shafts is dimited to one in which they rotate together, and another in which they rotate in topposite directions and The I former motion serves ecivto rotateithe articulated armetransferedevice, eand the latter 2032 Emotionposerveso to sextend; andwretract; otheriarticulated; arm? as to drive an articulated arm transfer. spiveb refaratione bas moskTheminner; shaft (is longer than the outer shaft (cand) the extremitystof othetrinner shafts outside sthet vacuum sichamber not extends beyond the corresponding textremity of the couter shaft and attains a maximum outer diameter corresponding to That of a not the outer shaft. TA rotor of is supported on the outer surface of the outer shaft 4, and a corresponding stator 18 supported outside ethed rotor of in Rimilarly, earprotor 9 is ; 90 supported rong the outer surface; of the sinner shaft 15, and a 30 Jud corresponding stator 10 is supported; outside the rotor 9. end Each statories part of a drive which rotates the corresponding ETT shaft on Asicappears; thereinafter, meeach rotors cissinside the filed Decembrancy solution is not seen that the second muusey to Each rotor-stator pair 57, 8 and 9, 10 may form partiof a 35 to conventional brushless iDC to to the same the same of the sa manufactured by MFM Technology, Inc., 200 Thirteenth Avenue, Ronkonkoma, New York 11779.

WO 94/23911 TOG PCT/US94/04040

remai eduRotaryxmotioniis imparted to ceach shaft by well-known 38 servomechanismittechniques, a wherein say suitable a signal by a stator clamp 37, erotate; etcliosistic constators of the color of babiyong The warying a position yof feach eshaft as itigrotates is 5, codetected by na suitable sensing mechanism in combination which a suitable coded disk or the like of For example, and coded my pattern of opaque portions on a transparent disk may be caused 71 -to pass between a light source and a light detector Inslieu ent of such van optical neensing mechanism; a magnetic sensing 10202 mechanismo may ebe employed: wherein pea rcoded to pattern magnetized portions on a magnetic disk may be magnetically the sensing mechanismic may be Alternatively, is, mechanical) such as a scombination of a gear and as witch, or it may be acoustical diwith arotation of reach, shaft aproducing 150: coded clicks of some sort; feven electrostatic systems may be c. designed a Forepurposes of dillustration, and without limiting which the ascoper of the minvention othereto, sand optical asensing movable drive housings arcbedrasadentiliwa mains aldavom eff. 30 Ardiskell ispaffixed; to the outervextremity to the outer 20 aug shaft 4 sbyba a clampiplate s12 to This adisk shasha coded apattern bas of opaque portions which pass between a dight-emitting-diode aidhousingi 13 olanda alareadaiheadac14, bfromawhichd ayssignal is _ap_transmitted:sto athercappropriate sexternal accircuit sthrough a and signal of eedthrough 115:0 The glight emitting diode thousing 13, 25 gd the read; head; 14; and the signal; feedthrough c15 care supported gronga drive chousing 1:16 awhich is of ixed cande forms spart of a noivacuum-tight tubular casing 17. a The rotor 7 siscaffixed to the priouter vshaftv4, randrethemstator: 183 is saffixed betoethe drive apshousings16 by arstator:clamp.18; positioned; sorthat:the stator 30 gvi 85 cans-co-actawith the motor Asscandatwoobearings=197s 202 are entrovided between the outerashaft 4) and the corresponding drive Dirhousing 16 upon which that udrive [is mounted: b:Similarly, a edidisk, 31 is affixed to the outer extremity of the inner shaft 10 50 by 3 a relamp plate 32 59 fThis disk has aregoded apateem of 35 go jopaque, portions which pass between audight emitting diode zamhousingarandara read bheadara4 ri from which vai signal is and transmitted to a the mappropriate sexternal circuit through a

WO 94/23911 TO9

mwomsignal feedthrough 35.03 The rotor 9 isoaffixed sto the inner shaft: 5,9 and the stator 10 is affixed to the drive housing 36 by a stator clamp 37, positioned southat the stator 10 can coai Fact with the rotors 9 frand two bearings 238 7 39 are provided 50 in between the inner shaft 5 and the corresponding drive housing bebo36 Supon Which that drive is inounted to beboo eldstive s beausped The drive housings 167 36 are of special configuration, ueiland provide an important partuof the vacuum tight casing 17 Palswhich separates the evacuated regions of the device from the atmospheric-air regions of the device. The two drive housings Villare similar in shape and are connected to each other by an Alternatively, the sensing mediopings TO Wortical motion may be imparted to the shafts by vertical gaicmovement sof the drive housings which in turn are supported on 15ad Atworlinear slides 0410 and two blead screws 42.astAlternates toll painthe lead screws with rotary motors may be linear motors a (servo paixor a stepper) or a voice-coildior a solenoid. To The evertically movable drive housings are separated from the mounting flange Ted by suitable mbellows 143, stand the Louter extremity of the 20ame:outermost drive housing is closed off; by an end cap 44 sa Thus 68 abo the centire region within the bellows warive housings (and) end si capp mays bedievacuated, fandbifrictionals motion inside of his s devacuated region is limited to that sofethe cvarious bearings. LE gara Each drive housing has a portion which passes between its 25 bed respective crotor and stators and sufficient clearance must be 32 s iprovided between the rotor and this part of the drive housing. edd od čela prioria rudevice i selventi na selventa i s sviis imparted to the articulated armstransfer device by rotating rotthe crotate spluggenextension and cretractions of the froglegs 30 sasis achieved by acounter rotation of the extend/retract drive 08 evishafts nooTherstructures of Sthespresent invention reduces the s , númber and type nof seals vrequired by the use of concentric disshafts constructed in a particular way. bane prior art device lo shows that control may be effected by (1) simple rotation of 35 aboa shaft and (2) counter-rotation of two shafts III the device 38 21 of the invention, "(1) is provided when the concentric shafts s frotate together and (2) is provided when the concentric shafts

WO_94/23911 79 PCT/US94/04040

asd Acounter-rotate of In this adevice rotary amotion rise not limited To Edbytherbasic mechanism, but may continue in meither direction an articulated arm transfer deviceelgns beriebb winswioin the 21 277,799The three motions: (vertical forotary and extend/retract) 153 dimay libe disimultaneously stactivated to provide fanys desired disdetrajectory of the end effector. TeOn the other thand tin some adfacapplications all athree motions and prot mecessarily be zi > activated; and the scope of the invention includes devices in Islandswhich only one or two lof the aforementioned three motions are 10 activated. moitem. 0. nwords equireferring now to Figure 4 in conjunction with Figures 1-3) (the louter shaft 4 is connected to one supper arm 151 and the out inner shaft: 5 is connected itorthe other suppers arm 152 lof an e siarticulated darm transfer/edevice such as athat ishown in the 15 3 2 aforementioned U.S. patent No: 57180, 276 π For θ motion π(i.e.) Empirotation of the send reffectors 53) both rotors 7; 9 turn in modification in infone direction (19) For a R Emotion 3 (1.e. extension reducand dretractions of sithe send seffectors and seach scrotor w7, 9 mirrors the other with equalizbut sopposites rotation. add These 2011 motions are computer controlled trusing tinputs; from the two shoulder assembly is mounted on the outer (rots.areboone, no end to no When Frotors 17; 2:9; turn in synchronism in cone direction, -bns-shafts-49053alsowturn in that-direction.s Referring-to-Figure 10 144; omificthe shafts 14, spiturn clockwise; the upper arms 151, 52 25 xup also turn clockwise oalong bwith withe rest of the apparatus s Conversely, if the shafts 4, 52 turn shown in Figure 4. reduccounterclockwise, the lentire apparatus shown in Figure 4 turns , ero counterclockwise. 22cIf a on other other thand, ethe couter shaft 4 edj turnstjeclockwise:elwhile eithe prinnerjjeshaft;urns 30 laucounterclockwise Lithe upper arm 51 will turn clockwise and the 8 upperoarm: 52 nwillolturn: counterclockwise, ed. Theiresulting bns movementicof bothmendieffectors [53mis) downward din Figure 4. adi Conversely, reifethe fouter shaft 4 turns counterclockwise while nao theminnershafte5sturns clockwises thefuppercarm i51 wills turn 35:oia counterclockwise .andethesuppersiarm 520 will eturn#clockwise 35 ed vThe (resulting:movement of both; end) effectors 153: iis supward in used. Figure 4.

WO 94/23911 79 PCT/US94/04040

Desimil soreferring now to Figures 6 and 7, the souter shaft 4 has moist affixed thereto sarblock 54 in which the supper slave arm 55 of an articulated arm transfer device such as that shown in the (staraforementioned co-pending application) Serial No. 1997, 773 is 5 is restatably supported. De The supper slave sarm 156 sof such an emos articulated arm transfer device is affixed to the sinner shaft ed vsisos as to rotate therewith slauthis scarcthest wo chafts hi serotate sinus ynchronism for a motion; but the souter shaft 4 is ers sheld fixed and sonly the sinner shaft ws is rotated for radial motion.

10 motion.

10 be savious 0.5

end fin Ifhersaforementioned Unstable Patents Nos met4,666,366 and me ic4,909,701 secheas shown din Figure 5): is imade with two end concentric shafts, dan outer shaft no protate ethegarms in 0 to motion and an inner, shaft to generate extend/retract motion; in mitties possible to protate the appropriate shaft no motion with one motor (and encoder) by using two brakes none of which quith contents the inner shaft to the couter shaft pand the other established the couter shaft pand the cother established to the data and the cother with outer shaft ito the couter shaft and the cother established the cother with engaging the cother with cother data are the casing of the cother with cother casing of the casing of the casing of the casing of t

In the ingress of the control of the casing and the two casing the case casing the case casing the casing

and protecting the outer shart, and therefore and model of the plant of the information and protecting the outer shart are larged and the information of the properties of the protection of the

WO 94/23911 PCT/US94/04040

at IstrauBy properadesign and ause sofomagnetic and non-magnetic Ems materials, mit is possible to mount all moving parts, wincluding ai obrake shoes and motor protors, sinside of a sealed cylindrical -musicasepiwhile placing thermagnetalcoils bofically components in 5 bas atmosphere outside the casing reThis will eliminate the known dose outgassing problems and electrical efeedthroughs which degrade raduperformance of systems having active electromagnets in vacuum. ST Ma While this mechanism will work with any of the extending end arm assemblies typical of robots manufactured by the assignee 10 bysof the instant application, a particular advantage is achieved when using the aforementioned arm shown in Figures 6 and 7 and 187 used in articulated arm transfer devices of the type disclosed examins the saforementioned acco-pending a application is Serial 7 No. (27 997,773, in that only one driving shaft is required at the 15:13 shoulder, eliminating the eneed of fgearing on top of the the stator 10 of Fig. 1, serves to rotate tathana gnitator Co. The salkeferring on owe to Figure 187 as mounting flange 61 is Trattached to an apertured region of the bottom wall of a vacuum anschamber within which an articulated arm transfer device 62 is 20zi supported. The articulated arm transfer device 625 is shown 02 ras being of the type shown in Figures 4 and 5. of The mounting flange itself has a centralisaperture through which two zairconcentric soutput dahafta rextend zaald The douter shaft is , sudesignated 63 [Tand the inner shaft is designated 645 LAE the extremities of the output shafts within the Wacuum Chamber a 25 -iipilot bearing 65 separates the shafts and supports them upon zi each cother is The itwo dishafts lare independently of otatable. However, in the device of Figure 8 only one shaft is foldatably Tandrivén by Jammotor, Tand afotation Liofa the 8 other shaft 30 snodeterminedabyatworbrakespeone of which to auses the shaffts to , serotate together;) and another of which causes the country , bato remain brixed courne brokmer inotion is erves to Trotate the Iscarticulated armitransfer device; and the latter motion serves erstoeextend and retract the articulated farm transfer device. 35 Led adda The inner shaft & salonger than the outer shaft, and the basextremity rofuthed inner shaft. Foutsides the Cvacuum bahamber

extends beyond the corresponding extremity of the outler shaft.

WO 94/23911 C

pica Agabrake 66% comprising a adiska 67 agof a magnetic material is prin supported on the outer surface of other outer, shafts 637 and [55] cooperates with a diska 68 a of magnetic material swhich is mi eslidably supported inside a casing 169 to finon magnetic procuum-5 montight sumaterial All and Albimagnetic socoil el70; tuwhen reference and provided a second el70; tuwhen reference and a second el70; t ebarmagnetizes the tdisks 367 po 68% so that they opress against each .mmyother: and macto as a brake, spreventing rotation mofathe souter ominshaft :63. No Similarly Amay brake #71 recomprising a andisk 72 of perchagnetic material is supported for Itherouter Surface mof the 1000 couter shaft 63, and cooperates with randisk 873 mofemagnetic 1 material which is slidably supported on the inner shaft 64. Daz A magnetic coil 74, when energized, magnetizes the disks 72, .5% 73 so that they press against ceach other and fact cas acbrake edd or coupling locking the shaftsato teach tother .: Atmotor 75, 15 and constructed similarly to the econstruction of rotors 9 and 1. stator 10 of Fig. 1, serves to rotate the inner shaft: 64. More specifically, a rotor 176 list supported nonethe outer mun surface of the inner shaft 64 psandsaucorresponding stator 77 is supported outside the rotor 76 as no The stator 77 sis part 20 mo of a drive which rotates the inner shaft 64 T The rotor 76 is 32 prinside the vacuum and the stator 77 is outside the vacuum. The rotor-stator pairs 76,5 77 may form parts of a conventional brushless on DC motor asuch asuthe Mr& KonSeries end manufactured by MFM Technology and 100 1 200 Thirteenth Avenue, extremities of the output shaft@7711: AroYi weWatamour a 25 noon mad Rotary motion is imparted to the cinner, shaft 64 by wellsknown servomechanism techniques, wherein arsuitable signal is However, in the device, retator, 77 to a di ni , revever ai that A disk 78 is affixed to the outer extremity of the inner od shaft 264 This disk has to coded pattern of vopaque portions of which pass through a suitable encoder 793 (which may comprise, ensfor example, a light-emitting diode housing and a read head, as from which a signal is transmitted to the appropriate external circuit through a signal feedthrough) to The shafts 63, 64 are en supported upon suitable bearings 65 2180 between the shafts 63, 88 18.64 and suitable bearings 81,382 between the outer shaft:63 and extends beyond the corresponding extremity of edeprises edter.

WO_94/23911 Of PCT/US94/04040

The casing 69 is of special configuration, and provides an important part of the wall which separates the evacuated regions of the device from the atmospheric air regions of the bequadevice as paired a pulsas a vacuum encloses.

is gaibulonVertical motion; may be imparted to the shafts: by ertical movement, of the casing 69 cin a smanner thereinbefore described

an outer shaft mounted Large Hithitigure of the mounted large mounted la

The casing 69 has a portion which passes between the printrotor 765 and statory 775 rand sufficient clearance must be 10 respectively between the rotor; 76 and the casing 69 tiwe and 0.

Having thus described the principles of the sinvention, together, with all lustrative membodiments thereof; it is to be understood that although specific terms are employed, they are swinkused in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth infective following aclaims, but no between rotats brodes a

I claim: ¿gnierod

a pilot bearing supporting said outer shaft upon said
inner shaft; and

- 20 means for causing each of said stators to impress a suitable electromagnetic field upon its respective rotor so as to impart retary motion thereto.
- 2 An apparatus for transferring objects, comprising: 25 a support;
- a first upper arm supported on said support so as to be rotatable about a first axis;
- a second upper arm supported on said support so as to be rotatable about a second axis;
- 30 means for causing said second upper arm to be driven by rotation of said first upper arm;
- a first pair of forearms articulated to said first and second upper arms;
- a second pair of forearms articulated to said first and second upper arms;
- each of said upper arms being of lesser length than each forearm:

WO.94/23911 79 PCT/US94/04040

The casing 69 is **2MTAID**cial configuration, and provides an important part of the wall which separates the evacuated regions of the device from prize in the case of the device from its interest of the case of the device from its interest of the case of the device from its interest of the case of the device from its interest of the case of the device from its interest of the devi

a vacuum enclosure having an aperture and arecapped 5soistubulars: members mounted rover said maperture and sincluding a bedirfirst edrive shousing and a second drive shousing; same were

an outer shaft mounted for a positive drive the casing of has a position; specion the casing of has a position; specion casing and formal must be sensitive that and conformation of the with and mounted on and inside said second drive thousing thus described the principles respiration, as to be together; that it is to be underst; that are inside the principles of they are underst; that are inside the purposes they are the part of the purposes sensitive that a they are underst; that are they are they are purposes that it stator should be a purposes

of limitation, the scope of the invention being ; grisuodin il

a second stator mounted on and outside said second drive housing;

a pilot bearing supporting said outer shaft upon said inner shaft; and

20 means for causing each of said stators to impress a suitable electromagnetic field upon its respective rotor so as to impart rotary motion thereto.

25

30

35

- 2. An apparatus for transferring objects, comprising: a support;
- a first upper arm supported on said support so as to be rotatable about a first axis;
- a second upper arm supported on said support so as to be rotatable about a second axis;
- means for causing said second upper arm to be driven by rotation of said first upper arm;
- a first pair of forearms articulated to said first and second upper arms;
- a second pair of forearms articulated to said first and second upper arms;

each of said upper arms being of lesser length than each forearm:

WO_94/23911_TO4 PCT/US94/04040³⁷

: galalramfirstsholding: means :pivotally coupled to said first pair of forearms and second holding means pivotally coupled to said ed osecond pair of forearms, an engagement between said first pair of forearms and adapted to spreventirotations of dsaid of irst 5:d cholding means and antengagement between said second pair of: forearms and adapted to prevent:orotationodofesaidsusecond a pair of forearms, comprising shmi; ansampnibloded a od bedalidriving:means:capable:ofodriving:said,firstcupper:arm for rotation:through:an;angle:in the grange cof afromagreater athan 10:Rs:120%sup:tomand,including:180%rtomoversaid first holding means 14 videbetweentladefirstolextended position landcagefirstisretracted supported on said link, and means for causislinwinoitizog one and simultaneously smoving resaid second holding means between a second retracted position and a second extended position; said 15 driving means sincluding the following components:52 15 biss no assvacuum lenclosure having an gaperture and a capped tubular member mounted over said aperture and including a firstadrive housing and a second drive housing; bisa reagn bisanwoutersshaftdmounted son dandsinside said first drive shaft; 20 housing by bearings; ; amuserclancinner ishaft within said souter ashaft and concentric therewith and mounted on and inside said second drive housing driving means capable of driving at leasing means diving mort to sanfirst rotor mounted for said wouter shaft amis reggu greater ;tardanien said und said som sa because direct stator mounted on and foutside said first drive said including the prizioning driving means a second stator mounted on and outside said second drive a vacuum enclosure having an aperture anignizuon ped 30s gnibulampilot bearing supporting said wouter shaft upon's aid 08 first drive housing and a second drive homeingland renni evirb dameansiforefcausing reach cofusaid stators uto dimpress a suitable electromagnetic field upon its respective rotor so an inner shaft wioteredthinoitomeratortragmiconesaric therewith and mounted on and inside said second drive housing 26 by bearings;

a first rotor mounted on said outer shaft;

WO 94/23911 TO9 PCT/US94/04040

efforearms and second holding means pivot; tropquapsed to said of forearms and second holding means pivot; tropquapsed to said second adapted of seamosproper arm supported on adapted to; airst pair of forearms and adapted to; airst pair of second pair of seamos and adapted to; airst pair are requisited pair of seams and adapted to ; airst should all all all all and a seamosproper arms, comparished and adapted to a pair of forearms, comprising an a pair of forearms, comprising an apair of forearms, comprising an apair of forearms and adapted to a pair of pair of conficulting and a seam of conficient and a seam and all all all and and a seam and all all all and a seam of conficient and con

10:nsem gmisaid blink imeansvccomprising; nabilink, brancupper: shaft: bedorotatably isupported on isaid; link, esaselower ishaft: crotatably supported on said link, and means for causing rotation of one a mahaftiin one sense to cause protation of the other shaft in the bisopposite; sense; and a second and a protected protected protected process.

said_first_mupper_tarm_[being_fixed_to_msaid_supper_tshaft; all being_rotatably_mounted on said being_rotatably_mounted on said being_rotatably_mounted on said tubust member mounted over said aperture; said_first_oforearm being_fixed_sto_said_slower_tshaft; being_rotatably_mounted_on_said_upper

20 shaft; ; therewith and mounted on and inside said second drive ibraing therewith and mounted on and inside said second drive ibraing

- an inner shaft within said jouter shaft and soncentric therewith and mounted on and inside said second drive housing as by bearings;
 - a first rotor mounted on said outer shaft;

WO_94/23911_TD9 PCT/US94/04040

bisa nistawsecond rotor/mounted sono said dinner a shaft; . 3 because as first stator mounted (on) and boutside deaid direct drive thereon, wherein said second shaft has a four; griavod of , Kaib briaisécondistatoramounted ontand toutside said secondadrive and wherein said casing has a fifth disk of magnet; prizuodial & bissenoquethadeerstoesbissespiritoring supporting said second disk, said first coil being adapted tibnge; thank rennield Maib Addimeans sform causing heach of isaid istators to simpress a bissuitable selectromagnetic field suponsits brespective rotor so 10 floas (to simpart rotary imotion theretogs bisa first shaft, and adapted to generate a mounted outside said casing gaissang4:02 Apparatusafor:simparting arotary amotion to Jamdevice gaiwithinca vacuum chamber comprising ain combination a bise a vacuum-tightatubularicasing of non-magnetic material, 15. said casing having a longitudinal axis, s mierera first shaft rotatably mounted inside said casing along Enssaid axis) isaid first shaft having a first disk of magnetic wherein a disk is affixed to smoored bathuom, laire batherein gaisass a second shaft rotatably mounted inside said casing about 20 said first shaft, said second shaft being tubular and having a second disk of magnetic material mounted thereon outside Apparatus in accordance with, findambinosembins a Disa mid first scoil mounted outside said casing and adapted to bacgenerate a magnetic field in said firstidisky bas , paisso 25 sisvilosacsecond coil mounted coutside said casing and adapted to generate a magnetic field in said secondidisk, brodes biss at least said first coil being adapted to generate a s first rotating field pattern for srotating said first shaft, busaid ffirstudisk beingd magnetizedsin baltpattern mefortbeing 30 birrotated by said first rotating field pattern. biss midia first shaft, said disk having a coded pattern of opaque ons shois en Apparatuse in faccordanced with claim 143 b wherein said second coil is adapted to generate a second cotating field pattern for rotating said second shaft, and wherein said 35 second disk is magnetized in a pattern for being rotated by said second rotating field pattern.

WO 94/23911 TO9 PCT/ÜS94/04040

6. ApparatusminSaccordancemwithsclaims430wherein said evirfirstrishaft chasiat third disk tofumagnetic material mounted thereon, wherein said second shaft has a fourth disk of evimagnetic material mounted; thereon; adjacent; to; said; third disk, and wherein said casing has a fifth disk of magnetic material a bismounted thereon inside asaid casing adjacent to keaid second disk, said first coil being adapted toungemerate camfield s apattern of ora pressing assaid second tdisk and assaid sfifth disk oz together:for:braking:action:coupling said:second:shaft to:said first shaft, said apparatus alsomincluding amthird acoil (1) 10 mounted outside said casing and adapted to generate a enimagnetic field in said third disk and fourth disk for pressing said third disk and said fourth disk together for braking _fsaction_coupling-said1secondsshaftgto3said1casing. _

15 said casing having a longitudinal axis,
gnols gnIosa Apparatus.ineaccordance.withsclaim 24.5 wherein a
a sensing mechanism is supported on and within said casing, and
wherein a disk is affixed to said first shaft, isaid adisk
suchaving a gcoded pattern madapted sto mactivate said sensing

20 said first shaft, said second shaft being tubul mainshaming 05 a second disk of magnetic material mounted thereon outside

8. Apparatus in accordance with claim 5770 wherein a seconds sensing mechanism bis r supported on cand within said casing, and wherein a second disk is affixed no said second

25 stavitosa otados de privatados de privatados de la estada de consecuencia de la consec

30 bissotot: Description in the properties of th

second disk is magnetized in a pattern for being rotated by **25** said second rotating field pattern.

30

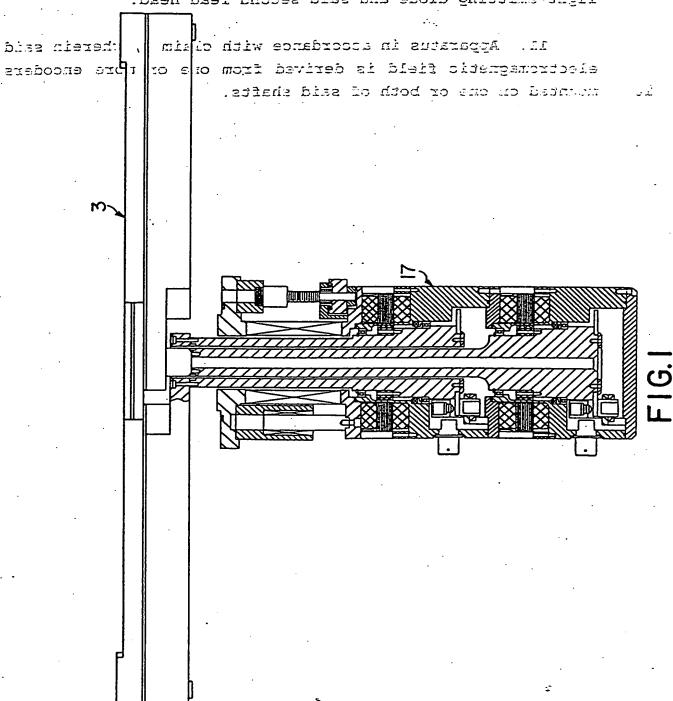
WO 94/23911 9 PCT/US94/04040

10. Apparatus in accordance with claim 8, wherein a second light-emitting diode and a second read head are supported on and within said casing, and wherein a second disk is affixed to said second shaft, said disk having a coded pattern of opaque portions adapted to pass between said second light-emitting diode and said second read head.

Apparatus in accordance with claim 1, wherein said electromagnetic field is derived from one or more encoders mounted on one or both of said shafts. 10

WO 94/23911 > PCT/US94/04040

10. Apparatus in accordance with claim 8, wherein a second light-emitting diode and a second read head are supported on and within said casing, and wherein a second disk is affixed to said second shaft, said disk having a coded pattern of cpaque portions adapted to pass between said second light-emitting diode and said second read head.



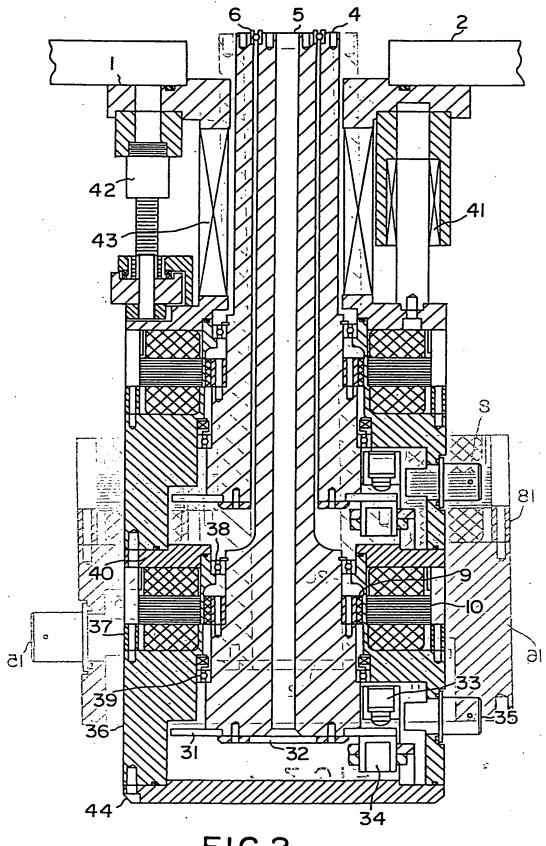


FIG. 2

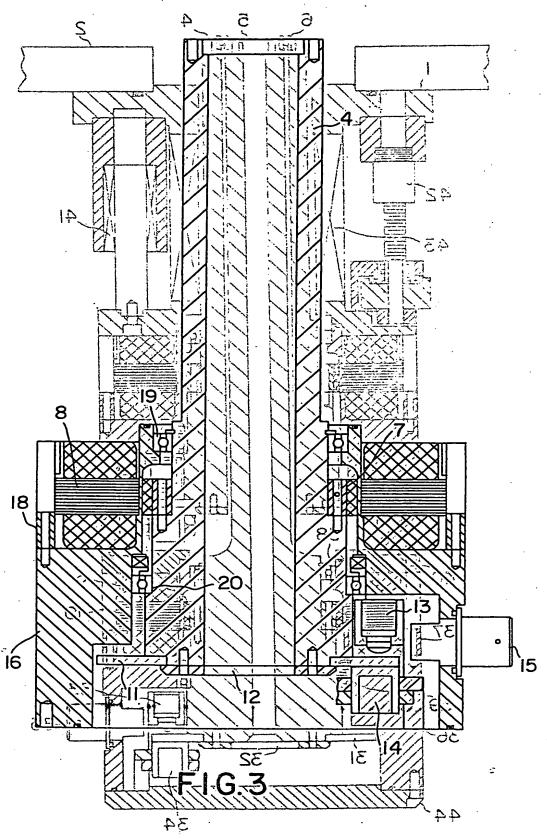
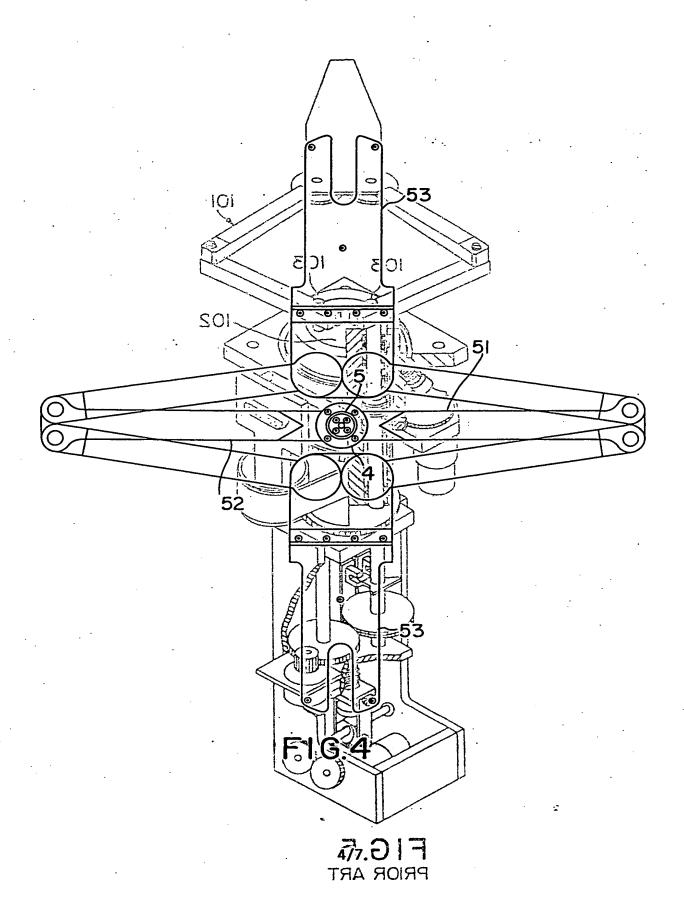


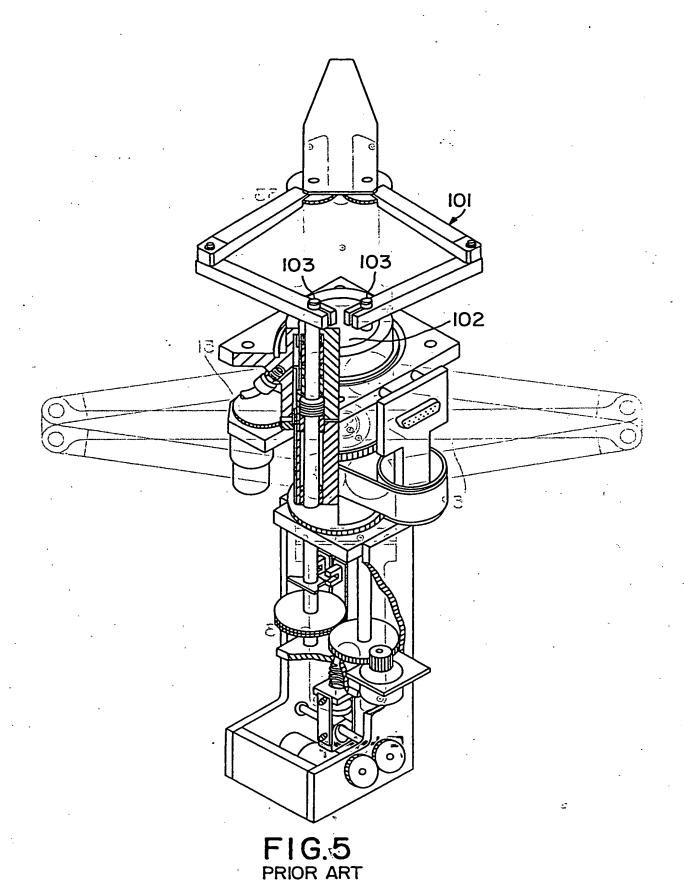
FIG7,2

WO.94/23911 79 PCT/US94/04040

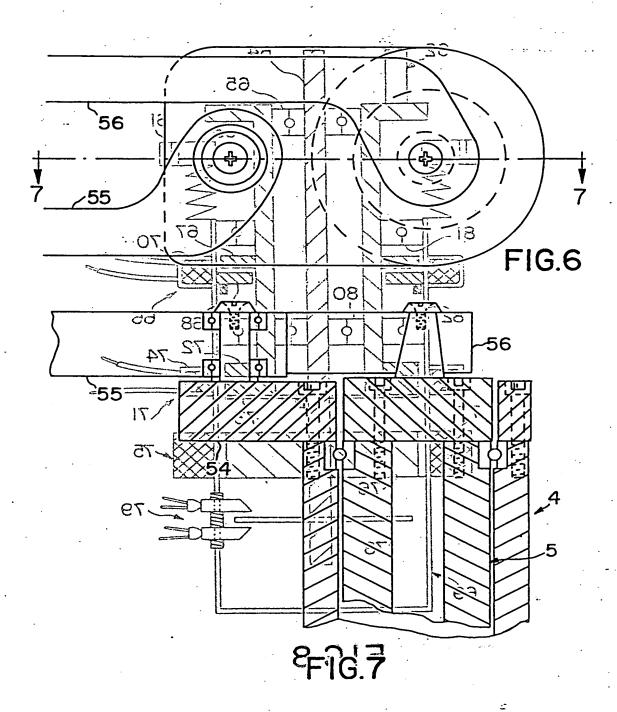


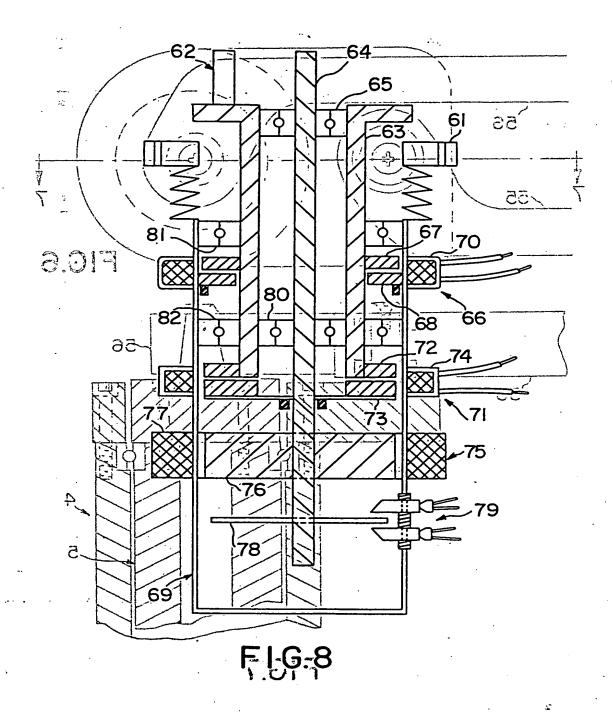
5/7

₩O 94/23911 mg PCT/US94/04040



5/7





INTERNATIONAL SEARCH REPORT EDEAGE CA International application No. PCT/US94/04040

	A. CLA	SSIFICATION OF SUBJECT MATTER (See baus) staw smith rises a sed and	Bar I Chart
	US CL	:B25J 21/00; H02K-16/00 :414/744.5; 901/23; 310/114; 192/18B is mixture to secret in bestellation mad son sed some continuous international Patent Classification (IPC) or to both national classification and IPC	lescionesei sidi
			i. D Chima
	Minimum d	ocumentation scarched (classification system followed by classification symbols)	tuacad
		414/744.5, 744.2; 901/15,23,24; 310/67R, 75D, 88, 101, 103, 112, 18B, 12D; 74/479 BP	
	Documental None	tion searched other than minimum documentation to the extent that such documents are included a searched other than minimum documentation to the extent that such documents are included as $3 - 1.20 M_{\odot}$	balance eblain and ni b
น่อมะ	Electronic d	lata base consulted during the international search (name of data base and, where practicable	search terms used)
	None	हार the sel medials of inconsistent control control out to correct out, specifically : Esten these.	
	C. DOC	UMENTS CONSIDERED TO BE RELEVANT	
.(Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	X	US,A, 5,270,600 (Hashimoto),14 December 1993,	1,4,5,113
	Y	Figure 7	2,3,7-10
	Υ	US,A, 5,180,276 (Hendrickson) 19 January 1993; Figure 1B	2,3
	Υ.	US,A, 4,712,971 (Fyler) 15 December 1987	2,3
	Y	JP,A, 2-292153 (Fuji Electric Co. Ltd.) 03 December 1990 Figures 12b (claim 2) and 9 (claim 3).	2,3
archable	Y Lida 8159050	US,A, 3,768,714 (Applequist) 30 October 1973 elements 156,160,166.	7-10i
naymen.	id not invite	carchable claims could be scarched without effort justifying an additional fee, this Authority additional fee.	, , ,
t coven	ו מפגייכה דכסי	some of the manined additional search fees were timely paid by the applicant, this internation	70 PA DE 05
	Furth	er documents are listed in the continuation of Box C. See patent family annex.	culy tin
	•	cial categories of cised documents: The later document published after the interest date and not in conflict with the application of the conflict with the conflict with the application of the conflict with the application of the conflict with the conflict with the application of the conflict with the application of the conflict with the application of the conflict with the conflict with the application of the conflict with t	ation but cited to understand the
4	.E. cet	tier document published on or after the international filing date "X" document of particular relevance; the considered novel or cannot be considered novel or cannot be considered when the document is taken alone	se claimed invention cannot be
ri noqo	್ಟಿಯ ನಾನ್ಯ ಪ್ರಾಧ್ಯ ಕ್ಷಮ ನಾನ್ಯ ಪ್ರಾಧ್ಯ ಕ್ಷಮ	"Y" "Y" "Y" "Y" "Y" "Y" "Y" "Y"	s step when the document is to documents, such combination
	P doc	remost published prior to the international filing date but later than "&" document member of the same patron priority date claimed	•
		Date of mailing of the international search 0 5 JUL 19 1994. The additional search fees were accompanied by the applicant's pro-	94
		The additional search for were accompanied by the applicant a process of add SUNASI and the payment of add SUNASI and to estable guilland	Michael Contract
	Commission Box PCT	ner of Patents and Trademarks	
	_	a, D.C. 20231 ★(TV Vivi((1) hers and le noitsumines) 9 C703) 305-3230 Telephone No. (703) 308-1112	Form POTASAURI

.091 go that INTERNATIONAL SEARCH REPORT INTERNATIONAL application No. PCT/US94/04040 PCT/L'S94/34040

	Box I Obse	rvations where certain claims were found unsearchable (Continuation of item 1 of first she	(A. ((a)	
Ī	This internation	nal report has not been established in respect of certain claims under Article 17(2)(a) for the following Du bns noitesulismaic classical end of the (Ull) noitesulismaic reports of the content of the c	g reasons:	
	느니은	ause they relate to subject matter not required to be searched by this Authority, namely:	10. 112	
	UCX		- 1	
		416/744.5, 744.2; \$91/15,23,24; 310/67R, 75D, C8, 101, 103, 112,	;	
_ .		(162, 12D; 74/479 BP		
: hc	the fields sear	tion searched other than minimum decomments to the extent that ruch documents are included in	Document	
- 1		·	Pione	
	2. X _CL	ims Nos.: 6 ause they relate to parts of the international application that do not comply with the prescribed requ	ا ما ترونندانداندان	ah
(E)	३७ शामात्रा व b ळ	extent that no meaningful international search can be carried out, specifically:	in the second to a	sucn
- 1	au	cancil that no meaning in and in the control of the	eno#!	
	Please	See Extra Sheet.	. !	
_				
1		DEMERNES CONSIDER TO BE RILEVANY	C. Dec	•
_ :	3. C1	ims Nos.:		
-1	bec	ause they are dependent claims and are not drafted in accordance with the second and third sentences	of Rule 6.4(A).
ŀ	18 20 1	C. S. CONTROL Management (C. M. Congress M. CONTROL & C. M. S. CONTROL	· ·	
1	Box II Obse	rvations where unity of invention is lacking (Continuation of item 2 of first sheet)		
Ţ	This Internati	onal Searching Authority found multiple inventions in this international application, as follows:		
ı	1 ma mecinan	Unit scalding Additing today mempio mempio membio 1. — Second of Proceedings	. •	
1		US,A, 5,180,276 (Hendrickson) 19 January 1993;		
1	٤,		,	
ı		Spure 18		
l	_			
1	. 3,	US, A, 712,971 (Fyler) 15 December 1987	. Y	
I	, 3	,	Y	
		Figures 12b (claim 2) and 9 (claim 3).		į
ı				1
ı	· LD2[=	all required additional search fees were timely paid by the applicant, this international search report	t covers all so	 archable
		elements 156,160,166.		
١				
1		all searchable claims could be searched without effort justifying an additional fee, this Authority	lid not invite	paymen
1	of	any additional fee.		
- 1	3. T As	only some of the required additional search fees were timely paid by the applicant, this internation	j il search repo	l irt cover
		y those claims for which fees were paid, specifically claims Nos.:	اسسا	1
_ .		Note that the state of the stat		
		saiel orangorios ef ciest documents: "I" inter document publiched after the internal date and act in conflict with the application	•	
		runties defining the grantal acts of the art which is not occurdent principle or theory underlying the sevention of periodical references.		1
		her decreases resident on or efter the interestational filtre deter "X" document of particular relayance; the cit		
3 V	astar da svioves (considered novel or cannot be considered to the		
on!	e soiterval trans	d to establish the publication date of another contion or other	alita	
73: .ru	4.5 a = No	required additional search fees were timely paid by the applicant. Consequently, this internal	jonal search	report is
	res	tricted to the invention first mentioned in the claims; it is covered by claims Nos.:		1
	4	among published prior to the interpolational filing date but hater them "2" document someher of the sense pures fumi priority date chareed		
-	רכספת	actal completion of the international search Date of mailing of the international search		1
1	1	1005 1111 7004		l
	Demark as 1		21 JUNE	1
[:	Remark on	The single barreds of the second and appears a process of the second and appears and appears a process of the second and appears and appears a process of the second and appears and appears a process of the second and appears and appears a process of the second and appears and appears and appears a process of the second and appears and appea	- b · · ·	1
	Berline	No protest accompanied the payment of additional search fees bits gailles	Neme sun n	1
Ļ		A/210 (continuation of first sheet(1))(July 1992)*	LUX XUL	1
	rom rci/is.	A/210 (continuation of first shoct(1))(July 1992)*	الألثقيستقدن تسمحه	:

INTERNATIONAL SEARCH REPORT

International application No. PCT/US94/04040

BOX I. OBSERVATIONS WHERE CLAIMS WERE FOUND UNSEARCHABLE

2. Where no meaningful search could be carried out, specifically:

Claim 6 appears to be directed to the structure in figure 8 but depends from claim 4 which is directed to the structure in figure 1. Since the two figures are directed to different drive structures it is unclear what structure is being claimed. It appear maybe first coil in line 7 of claim 6 should be second coil.

Form PCT/ISA/210 (extra sheet)(July 1992)*

This Page is inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

u	BLACK BURDERS
	IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
	FADED TEXT OR DRAWING
	BLURED OR ILLEGIBLE TEXT OR DRAWING
	SKEWED/SLANTED IMAGES
	COLORED OR BLACK AND WHITE PHOTOGRAPHS
	GRAY SCALE DOCUMENTS
	LINES OR MARKS ON ORIGINAL DOCUMENT
	REPERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
	OTHER:

IMAGES ARE BEST AVAILABLE COPY.
As rescanning documents will not correct images problems checked, please do not report the problems to the IFW Image Problem Mailbox